SIKHAY

Composition and Biodiversity of Gastropod Communities in Ogod River, Donsol, Sorsogon, Philippines

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Abstract

Gastropods are considered one of the most diverse groups in the Phylum Mollusca, primarily functioning in ecological litter decomposition and nutrient cycling. Aside from its detritivorous function, gastropods serve as prey for multiple predators. One of its predators is the firefly larvae. The presence of a notable abundance of fireflies in Donsol, Sorsogon, has positioned it as an ecotourism destination for firefly viewing in the Philippines. Given the association between firefly larvae and gastropods in terms of predator-prey interaction, this study aimed to assess the composition and biodiversity of gastropods potentially serving as prey for firefly larvae along the Ogod River in Donsol, Sorsogon. Employing purposive sampling focused on areas with abundant fireflies, a total of 10 sampling points (SP) were designated, wherein SP 1-5 are zone 1 near less anthropogenic areas, while SP 6-10 are zone 2 near anthropogenic areas. Standardized collection protocols were used, involving a two-minute timeframe for manual hand collection at all sampling points. The data analysis recorded a total of 82 specimens distributed across three orders, spread across three families, and under three genera. The most prevalent species identified was *Littoraria lutea (F=34)*, while *Vittina coromandeliana* was also present in both zones but accounted for only one specimen per zone. It is important to note that this study is confined to the identification of gastropods as potential prey for firefly larvae. Recommendations for future research include higher temporal and spatial surveys, *in-situ* predation experiments, molecular analysis, and the examination of environmental conditions to better understand the correlations between gastropods and fireflies.

Keywords: *biodiversity, Donsol, firefly larvae, gastropod, identification, mangroves, Philippines*

Introduction

The class Gastropoda, which includes snails and slugs, is recognized as one of the most ecologically diverse groups within the phylum Mollusca (Sao Mai, 2014), as this class is known to be the second most diverse invertebrate next to arthropods, accounting to 80,000 to 135,000 species (van Bruggen, 1995). The Philippines alone records 31% with 2-4% of it being endemic in the country. Some native and endemic gastropods in the Philippines include *Pila luzonica* (Reeve, 1856), which is spread out within the country, *Jagora dactylus* (I.Lea & H.C.Lea, 1851), which is restricted within Bohol, Cebu, and Guimaras, and even *Torotaia mindanensis* (Bartsch, 1907), which is recorded in Leyte, but is now seen within nearby provinces (Jumawan et al., 2016). Meanwhile, there have also introduced snails in the country. A few of these snails include *Pomacea canaliculata* (Lamarck, 1822), which is commonly known as the golden apple snail or channeled apple snail, and *Lissachatina fulica*

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(Bowdich, 1822), also known as the giant African land snail, which are considered major agricultural pests in the country and worldwide (Schneiker et al., 2016; Gabbeti et al., 2023).

Morphologically, gastropods are characterized by the presence of a univalve or single valve, calcareous shell that is coiled or uncoiled (Vermeij, 2015). Some members, like slugs, lack these characteristics and appear naked (South, 2012). Focusing on their shells, gastropods can display a wide range of sizes. Certain species have shells measuring around 25 mm in length, while some can be a little smaller, with around 0.5 mm. Some species can also grow as large as 60 cm, depending on the species (Johnson et al., 2019). Gastropods can thrive in diverse ecosystems ranging from moist and cool environments, such as rainforests, to tidal shores and mangrove areas (Baderan et al., 2019). Generally, gastropods are characterized by low activity levels, aptly described as "sluggish," a term derived from the word "slug" (Wyeth, 2019). They rely on their shells and reclusive behaviors as defensive mechanisms against potential threats (Garrity, 1984).

In terms of ecological functions, gastropods play essential roles in maintaining ecological balance as they contribute significantly to processes such as nutrient cycling (Hogarth, 2017). Brady & Turner (2010) mentioned that these gastropods participate in plant litter decomposition as they degrade leaf litter samples from their *ex-situ* experiment. Gastropods provide decomposition processes, converting leaf litter into essential nutrient derivatives used by other organisms (Graca, 2001). Meyer et al (2013) also verified the capacity of terrestrial gastropods as decomposers of leaf litter in the Hawaiian rain forest, indicating the ecological importance of these organisms in maintaining ecological balance. Their ecological functions also span from detritivory to predator-prey relations. The prevalence of gastropods in ecosystems can be attributed to their physiological and behavioral adaptations (Schweizer et al., 2019). Aside from their role as decomposers, they also serve as prey for various predators, including birds, fish, and other invertebrates (Covich, 2010). Specifically, juvenile fireflies or the larvae of fireflies are among those that prey on gastropods (Tyler, 2001; Fu & Meyer-Rochow, 2013; Allmon & Hendricks, 2021; Orstan & Novak, 2022).

The **Ogod River**, located in **Donsol, Sorsogon**, is an ecologically significant waterway well known for supporting firefly (*Lampyridae*) populations—one of the municipality's ecotourism attractions (Arquinez et al., 2020). Firefly larvae are predominantly predatory, feeding on small, soft-bodied invertebrates, with aquatic snails being among their preferred prey. The abundance and diversity of gastropods in the Ogod River may therefore have direct implications for the survival and reproductive success of these larvae, and consequently, for the sustainability of firefly populations. Despite the ecological and tourism importance of the Ogod River, there is limited scientific information on its gastropod composition and the potential role these species play in the firefly food web; therefore, this study aims to bridge that limitation. Understanding the diversity, abundance, and distribution of gastropods in the river can provide valuable insights into habitat quality, prey availability, and conservation needs. Such information is vital for formulating management strategies that support both biodiversity conservation and the sustainability of ecotourism activities in the area. With these gaps, the objective of this study is to identify and classify gastropod species present in different sampling sites along the Ogod River and determine their biodiversity values.

Methodology

Research Design

This study adopted a descriptive research design, encompassing both field collection of specimens and subsequent laboratory analyses. The descriptive research design is selected for the present study because it aims to document and characterize gastropod communities in the Ogod River without the manipulation of any variables. This research design allows for systematic observation, identification, quantification, and analysis of gastropod communities to understand their distribution and diversity.

Entry Protocols

All research activities conducted in this study followed national wildlife regulations. A Wildlife Gratuitous Permit (WGP No. 2024-08) was secured from the Department of Environment and Natural Resources (DENR) before data collection, ensuring that sampling and observation of gastropods were carried out in accordance with ethical and legal standards.

Sampling Site and Sampling Method

The study was conducted at **Ogod River** (12°53′52″ N, 123°37′52″ E) in the Municipality of Donsol, Sorsogon. The river is recognized as an ecotourism site known for firefly-watching activities. The site is predominantly characterized by its aquatic nature, with mangrove trees encompassing the area, serving as habitat for both gastropods and fireflies. The collection site is not included in the Ticao-Burias Pass Protected Seascape (TBPPS) as seen in this geospatial map provided by Donsol Municipal Environment and Natural Resources Office (MENRO). (https://www.arcgis.com/apps/mapviewer/index.html?webmap=29e5285760fa466791ae12334dfbc830)

A geospatial map of the study site was produced using QGIS v.2.14.21 (Figure 1). Data collection was conducted once last June 24, 2024, using opportunistic random sampling, establishing 10 sampling points (SPs) that served as quadrats and were distributed along the river course, considered as a single line transect. Each sampling point was marked with GPS coordinates and described in Table 1. To distinguish potential human influence, the sampling points were classified into two zones based on the presence or absence of anthropogenic activity. Classification and zonation were determined by proximity to the **Putiao–Pilar Road Bridge**, which marks the river's entry point. Initially, a boat ride a day before the collection was done to mark areas where fireflies are congregating. Additionally, input from local sources influenced the selection of sampling points. Sampling points in proximity to anthropogenic areas (Zone 2) include SPs 4, 5, 6, 7, and 8, while SPs 1, 2, 3, 9, and 10 are designated as being without or situated away from anthropogenic areas (Zone 1). The digital mapping of these sampling points is presented in Figure 2.

Figure 1. Map of collection site in Ogod River, Donsol, Sorsogon. QGIS v 2.14.21

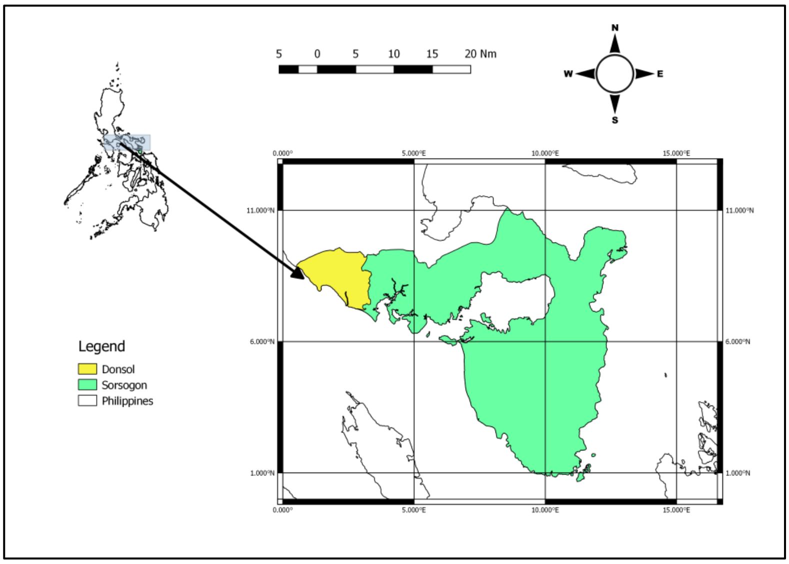


Figure 2 Digital map of sampling points Line in the image signifies division among two zones. The five topmost point (red marker) is Zone 1 while the lower five points is Zone 2.

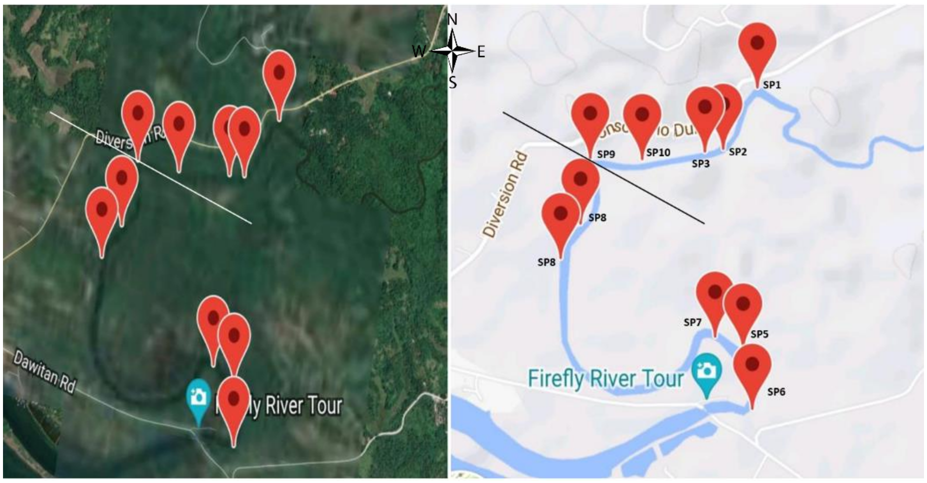


Table 1. GPS coordinates and description of sampling points within Ogod River in Donsol, Sorsogon.

Zone	Sampling Point (SP)	GPS Coordinates	Description
1	1	N 12°54'38.35752", E 123°38'0.30896"	Situated on the left side of the river, with an altitude of 17 m ASL. This site is the farthest from the starting point of the boat tour. The area is purely surrounded with water

(not anthropogenic)	2	N 12°54'29.30807", E 123°37'54.88734"	Situated on the right side of the river, with an altitude of 16 m ASL. The area is purely surrounded by water.
	3	N 12°54'28.96195", E 123°37'51.96437"	Situated on the left side of the river, with an altitude of 16 m ASL. The area is purely surrounded by water.
	9	N 12°54'27.97434", E 123°37'33.6886"	Situated on the left side of the river, with an altitude of 9 m ASL. The area has a soil portion allowing collection within it.
	10	N 12°54'27.84492", E 123°37'41.96375"	Situated on the left side of the river, with an altitude of 5 m ASL. The area has soil portions allowing collection within it.
2	4	N 12°54'18.29667", E 123°37'32.13023"	Situated on the left side of the river, with an altitude of 5 m ASL. The area is purely surrounded by water.
(anthropogenic)	5	N 12°54'1.68151", E 123°37'53.57606"	Situated on the right side of the river, with an altitude of 4 m ASL. The area has a soil portion allowing collection within it.
	6	N 12°53'51.08173", E 123°37'59.55743"	Situated on the right side of the river, with an altitude of 11 m ASL. The area has soil portions allowing collection within it.
	7	N 12°53'59.94157", E 123°37'58.04574"	Situated on the right side of the river, having altitude of 5 m ASL. The area has soil portions allowing collection within it.
	8	N 12°54'13.2598", E 123°37'28.98857"	Situated on the left side of the river, with an altitude of 5 m ASL. The area is purely surrounded by water.

Collection Design

Given that the collection method limitation involves boat-based procedures, a uniform protocol was made. The standardization of gastropod collection time was set only at two minutes for each sampling point. As the sampling area predominantly lies within a body of water, the collection technique is confined or limited to capturing specimens at the given time. In instances where the boat is unable to reach the river's edge, the sampling point for that specific area is recorded as having zero collected species. In cases where the boat reaches the edge, but no soil area is present, collection is done within the boat, specifically collecting along mangrove branches, leaves, and flower areas. If soil is present within the sampling point, collection is executed within the soil, leaf litter, along the mangrove tree roots, within its branches, and within its leaves. The specimens are manually handpicked and subsequently placed into circular plastic containers measuring three inches in both height and diameter. After collection, specimens were transferred to a different container with the same dimensions and immersed in 95% ethanol for preservation.

Morphological Identification and Verification

The collected gastropod samples were processed at the Far Eastern University Animal Research Laboratory. Specimens were imaged on their abapertural and apertural views using a Leica DFC 295 camera mounted on a trinocular stereomicroscope (Olympus SZ-61), and the images were processed with ToupView software. Image stacks were subsequently compiled using Helicon Focus Pro v.7.7.4. Recorded images were analyzed for their shell morphology mainly on length (mm), number of whorls, shell coiling, umbilicus, shape, and color/patterns. Documented photos were cross-referenced with Abbott & Dance (1989) and databases from WoRMS Editorial Board (2023), MolluscaBase (2023), and Canadian Wildlife Federation (2009). The specimens were subjected to photo comparison documented from the National Museum of Natural History in Manila, Philippines, and other relevant literature, to give a putative identification per shell. Recorded images and their putative ID were submitted to Mx. Jerlyn Sarino of Conchology, Inc., based in Lapu-Lapu City, Cebu, for verification.

Data Analysis

Frequency and Relative Abundance

Data from the ten sampling points (SPs) were tabulated to list and record the presence or absence of each species and its frequency across the 10 SPs and across two zones. After which, the Relative Abundance (RA) of each species was calculated using Equation 1 presented below. Results are expressed as percentages to reflect each species' proportional contribution to the community.

$$\text{RA (\%)} = \frac{n_i}{N} \, x \, 100\% \qquad \textbf{(Eq. 1)}$$

Wherein,

n_i = number of individuals of species i, and
N = total number of individuals recorded across all sampling points

Diversity Indices

Ecological Statistics were employed to evaluate the structure and composition of the sampled community. All computations were performed using Microsoft Excel (v. 2016). The statistical tools are presented below.

A. Shannon-Weiner (H') Diversity Index

In understanding diversity, an ecological statistic usually being employed is the Shannon-Weiner Diversity Index (H'). This diversity index indicates how diverse the species are in a specified area (Fouché et al., 2016). To calculate the value of Shannon-Weiner (H')

Index, the quantity of every species was accounted for, along with its ratio in relation to the total number of organisms. Then, the product of each species' proportion and the natural logarithm of that proportion was calculated and summed up. A higher value corresponds to a better diversity among areas of interest. The formula is seen in Equation 2 below as follows:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \qquad \textbf{(Eq. 2)}$$

Wherein,

H' = diversity index
s = the number of species
Ln pi = inversed proportion of individuals in each species belonging to the ith species of the total number of individuals

B. Simpson's (D) Index of Diversity

Another biodiversity statistic being utilized is the Simpson's (D) Index of Diversity. It is a measure used to quantify the diversity of a community or ecosystem based on the number of species present and their relative abundance. It considers both species richness (the number of different species present) and species evenness (the relative abundance of each species) in the calculation. The index ranges from 0 to 1, with a value of 1 indicating maximum diversity, and a value of 0 indicating no diversity (Kumar et al., 2022). In calculating Simpson's Index of Diversity, the formula is seen in Equation 3 below:

$$D = \sum n\,(n-1)/N\,(N-1) \qquad \textbf{(Eq. 3)}$$

Wherein,

N = total frequency of all species
n = total frequency of a particular species from which Simpson's Diversity Index, 1-D, is found

C. Sorensen Similarity Index (C).

To compare the two zones, the Sorensen Similarity Index is employed as a quantitative measure to assess the similarity between two ecological zones. The index is represented with a numerical value from 0 to 1 with the values closer to zero indicating low resemblance and values closer to 1 indicating high degree of similarity (Magurran, 2013). It is calculated using the Equation 4 below:

$$C = 2S/(A+B) \qquad \textbf{(Eq. 4)}$$

Wherein,

S = number of shared species across two communities
A = total number of species in first community
B = total number of species in the second community

Results

Identified Gastropod Species

A total of 82 specimens were collected and identified. The collected snails belong to three (3) Orders, three (3) Families, three (3) Genera, and six (6) species. The species' name and its morphometrics are summarized in Table 2. The representative photos are summarized per species description section. The occurrence or presence and absence of species are listed in Table 3. Further details regarding the frequency of each gastropod species within identified zones, as well as its overall relative abundance, have been outlined and shown in Table 4.

Table 2. Summary of the morphometric characteristics of the gastropod shells collected at Ogod River

No	Species Name	Mean Length (mm)	No. of Whorls	Shape	Shell coiling	Umbilicus	Color and pattern
1	*Littoraria lutea* (R. A. Philippi, 1847)	5.3	6-8	Conic-turbinate	dextral	Absent	Brown with Zigzag-like patterns
2	*Littoraria intermedia* (R.A. Philippi, 1846)	9.0	7-9	Conic-turbinate, spiral ribs are deeper	dextral	absent	Darker brown with a more exposed zigzag line pattern
3	*Littoraria pallescens* (R. A. Philippi, 1846)	6.5	7-8	Conic-turbinate	dextral	Absent	yellow, brown, orange, Some with visible zigzag patterns
4	*Cerithidea quoyii (Hombron & Jacquinot, 1848)*	21	8	elongated conical, spire have prominent axial ribs	dextral	narrow to absent	Dark brown
5	*Cerithidea balteata* A.Adams, 1855	16.7	5-8	elongated conical, spire have prominent axial ribs	dextral	absent	Brownish grey
6	*Vittina coromandeliana* (G.B.Sowerby I, 1836)	7.75	2-3 (not prominent)	aperture entire, semi-globose	dextral	absent	black/brown with light zigzag around the whole shell

Among the gastropods collected, *Littoraria lutea* was the most dominant species across the two zones, with 34 specimens recorded, accounting for 41.46% relative abundance. This was followed by *Cerithidea balteata* with 21 specimens (25.61%) and lastly, *Littoraria pallescens* with 17 specimens (20.73%). The remaining species contributed smaller proportions to the overall community composition. For zone specific dominance, *L. lutea* is the dominant species for Zone 1 with 31 specimens. This is followed by *L. pallescens* with 17 specimens. Meanwhile, for Zone 2, *C. balteata* was the dominant species with 21 specimens. The dominance data might be affected due to the limitation during collection. In terms of distribution, differences were observed between the two sampling zones. *C. balteata* was exclusively found in Zone 1, suggesting a preference for the environmental conditions present in that area. *Littoraria intermedia*, *L. pallescens*, and *Cerithidea quoyii* were only found within Zone 2, whereas *Vittina coromandeliana* and *L. lutea* were present in both zones.

Table 3. Species checklist of collected gastropods observed per zone in collection area in Ogod River

Order	Family	Scientific Name	ZONE 1	ZONE 2	Frequency (F)
Littorinimorpha					
	Littorinidae	*Littoraria intermedia*	-	✓	6
		Littoraria pallescens	-	✓	17
		Littoraria lutea	✓	✓	34
Caenogastropoda *incertae sedis*					
	Potamididae	*Cerithidea quoyii*	-	✓	2
		Cerithidea balteata	✓	-	21
Cycloneritida					
	Neritidae	*Vittina coromandeliana*	✓	✓	2
Total					**82**

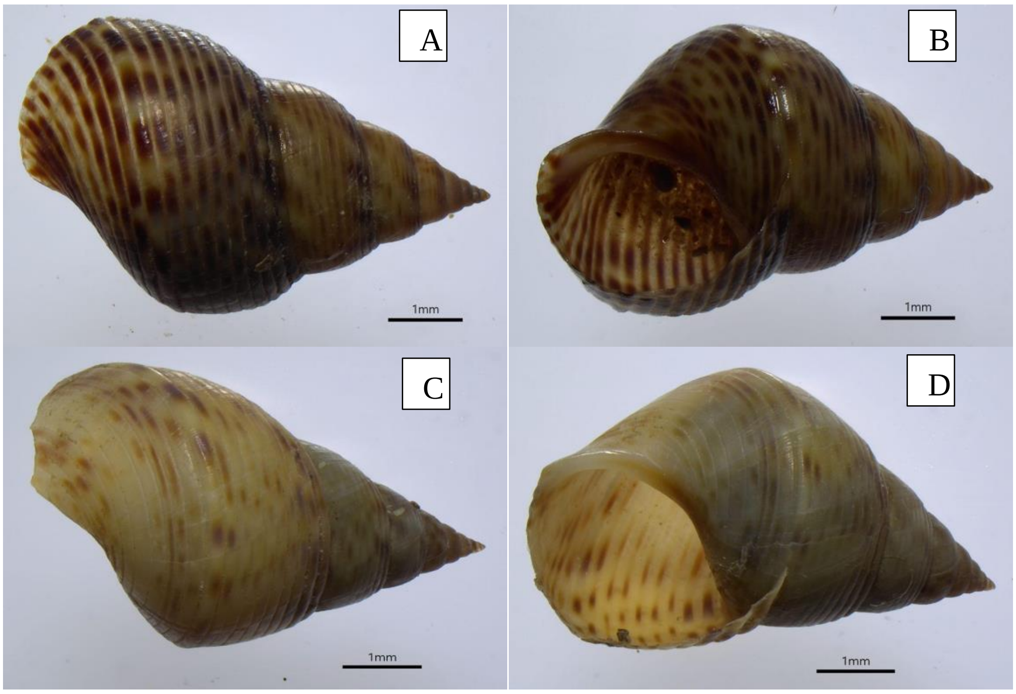
Legend: ✓- found; - not found

Table 4. Frequency of each species of collected gastropods along the two zones with its Relative Abundance (RA) of the collection site in Ogod River

Order	Family	Scientific Name	ZONE 1	ZONE 2	Frequency (F)	Relative Abundance (%)
Littorinimorpha						
	Littorinidae	*Littoraria intermedia*	0	6	6	7.32
		Littoraria pallescens	0	17	17	20.73
		Littoraria lutea	3	31	34	41.46
Caenogastropoda *incertae sedis*						
	Potamididae	*Cerithidea quoyii*	0	2	2	2.44
		Cerithidea balteata	21	0	21	25.61
Cycloneritida						
	Neritidae	*Vittina coromandeliana*	1	1	2	2.44
Total			**25**	**57**	**82**	**100.00**

Gastropod Description

Figure 3. Two variants of *L. lutea* based on color(A-B) Dark colored shell; (C-D) Light colored shell with clouded with cream callus. (A & C) Abapertural view; (B & D) Apertural view. Scale bars are 1 mm.



Material Examined. PHILIPPINES, LUZON, PROVINCE OF SORSOGON, Municipality of Donsol, Ogod River, (12°53′52″ N, 123°37′52″ E), Collectors: J.M. Manuel, A.I.G. Pag-Ong.

Diagnosis

Reid (1984) diagnosed *L. lutea* to have columella to be wide and excavated, with low ribs, coloration is polymorphic (yellow to brown) with brown specks. Height or length is up to 35 mm, with 7-8 total whorls. The spire outline is gently convex and its adult lip to be thickened without varices. Patterns within aperture are visible within larger and darker shells, however, they are clouded by a cream callus.

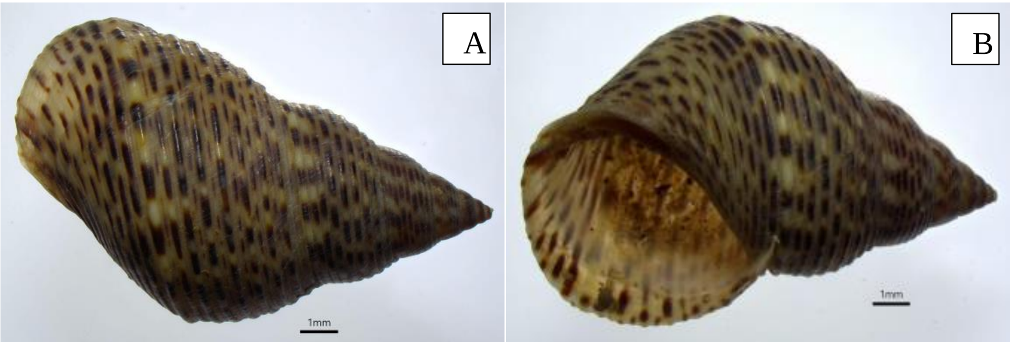
Distribution

Zvonareva & Kantor (2016) have mentioned that *L. lutea* are distributed across Indo-Pacific regions. Reid (1984) mentioned that *L. lutea* is distributed in the Philippines specifically along Masbate, Visayas, and records also from Mindoro.

Remarks

Personal assessment of all the specimens exhibited a small conic-turbinate shell morphology with a mean length of 5.3 mm and approximately six to eight whorls. The shell coiling is dextral with an absent umbilicus. The columella appears to be deep and big with its ribs appearing low and is yellowish to pale brown in color It has distinct zigzag-like patterns and are spotted or lined fecks). The spire outline is gently protruding and is convex in shape. The operculum is ovate and adult lip appear thickened. All these descriptions align with the descriptions of Reid (1994).

Figure 4. *L. intermedia* (A) Abapertural view; (B) Apertural view. Scale bar is 1 mm.



Material Examined. PHILIPPINES, LUZON, PROVINCE OF SORSOGON, Municipality of Donsol, Ogod River, (12°53′52″ N, 123°37′52″ E), Collectors: J.M. Manuel, A.I.G. Pag-Ong.

Diagnosis

Reid (1986) as cited by Zvonareva & Kantor (2016) described *L. intermedia* (size up to 32 mm) to be a marine gastropod usually located within roots, trunks within *Rhizophora* mangrove, but are sometimes also found within other mangrove species at elevation 0f 0.3 to 2.0 m above the soil. Predominantly associated with mangroves. The whorls within the snail spire are convex and narrowed, flattened spiral cords. Outer lip is thin while columella is wide and excavated. The operculum is ovate. Colors range from whitish to brown with patches of dark dashes along the spiral cords.

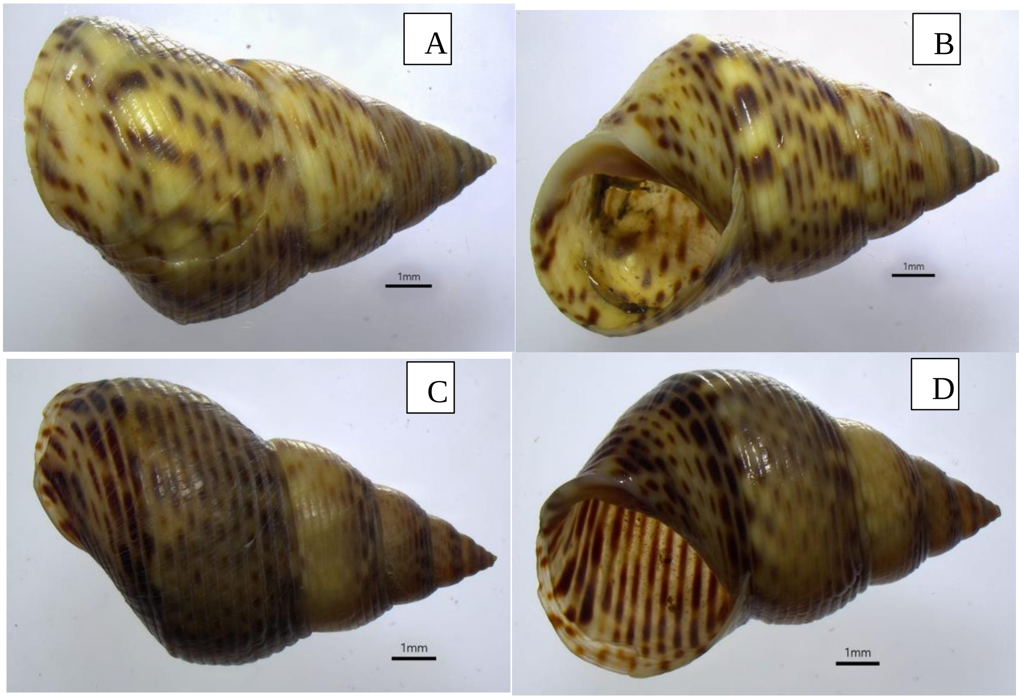
Distribution

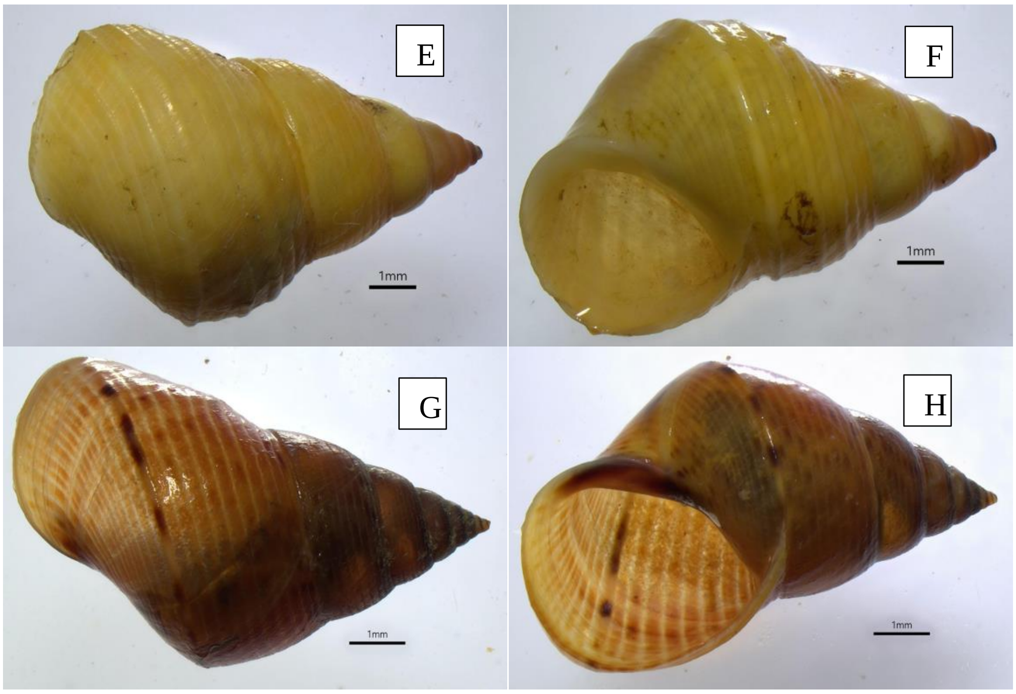
Velasco et al. (2018) summarized the distribution of *L. intermedia* to be widespread as this gastropod is found within Indo-West Pacific, East Africa, regions of Madagascar and Red Sea, up to Polynesian, Japan, Hawaii, and New Caledonian borders. This species is also distributed along Asian Countries such as Indonesia, Thailand, Vietnam, and Malaysia. In the Philippines, this species is spread within the country as it is seen along Cebu, Negros, Bohol, Masbate, and Bataan and even records from Northern Luzon.

Remarks

The collected specimens presented a larger conic-turbinate shell averaging 9.0 mm in length, with seven to nine whorls. The shell's deeper spiral ribs and darker brown pigmentation, coupled with more pronounced zigzag patterns, is dominant in the shell. Moreover, the coloration of brown and patches of black lines or spots are also detected within the specimens. The umbilicus is absent, the shell coiling within all specimens is dextral (common in *Littoraria*). The descriptions align with the descriptions of Reid (1986).

Figure 5. Polymorphic variants of *L. pallescens* based on color (A, C, E, G) Abapertural view; (B, D, F, H) Apertural view. Scale bar is 1 mm.





Material Examined. PHILIPPINES, LUZON, PROVINCE OF SORSOGON, Municipality of Donsol, Ogod River, (12°53′52″ N, 123°37′52″ E), Collectors: J.M. Manuel, A.I.G. Pag-Ong.

Diagnosis

L. pallescens is identified to be a marine gastropod with size up to 31 mm. It is usually found common along mangrove leaves and less frequent along trunks and roots. Elevation is within 1-4.5 above the soil and is dominantly attached to *Rhizophora* tree leaves. *L. pallescens* is predominantly mangrove-associated Zvonareva & Kantor (2016). The shell morphology of *L. pallescens* follows a polymorphic coloration (yellow, light brown, dark brown, orange), columella is wide and excavated, while its inner lip is callused and rounded. Ribs may be flattened or round, with spiral band on base (Reid, 1984)

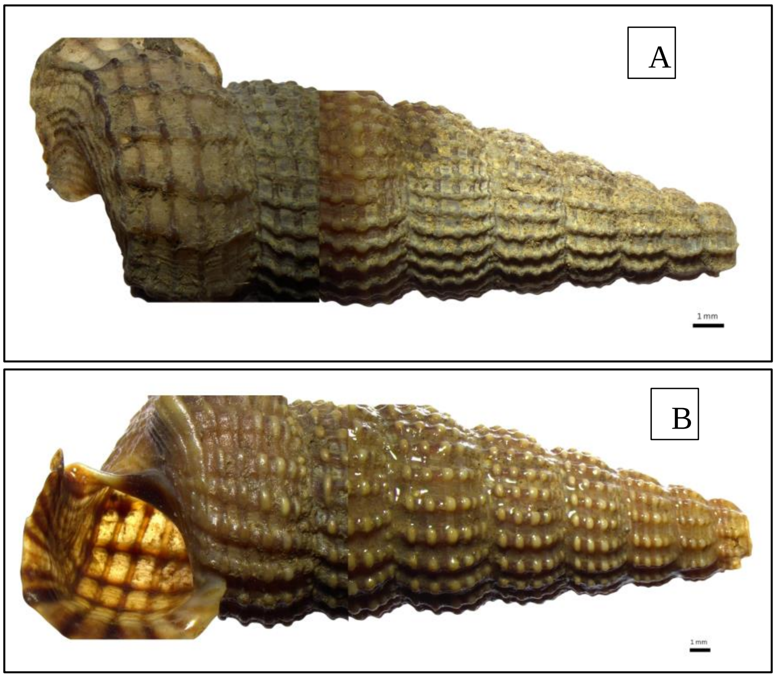
Distribution

Zvonareva & Kantor (2016) have mentioned that *L. pallescens* are distributed across Indo-Pacific regions. Reid (1984) mentioned that *L. lutea* is distributed in the Philippines specifically along Cagayan, Misamis, Bolinao, and Mindanao.

Remarks

The observed specimens collectively showed a moderately sized conic-turbinate shell (mean length 6.5 mm) with seven to eight whorls. The absence of an umbilicus and dextral coiling remain consistent with other *Littoraria* species found in similar habitats. The columella is deep and excavated, and inner lip is round in form. The ribs appear flattened and not prominent unlike other *Littoraria* species. Shell coloration varied from yellow to brown or orange, with some individuals exhibiting faint zigzag markings. The observed color variability suggests phenotypic plasticity possibly influenced by substrate type and light exposure within mangrove ecosystems. However, it should be noted that some specimens were collected in the soil area while some are within the leaves and branches of mangroves affecting their coloration, thus it should still need further investigation. Nevertheless, the morphology of the specimens collected aligns with the diagnosis of Reid (1984).

Figure 6. *Cerithidea quoyii* (A) Abapertural view; (B) Apertural view. Scale bar is 1 mm.



Material Examined. PHILIPPINES, LUZON, PROVINCE OF SORSOGON, Municipality of Donsol, Ogod River, (12°53′52″ N, 123°37′52″ E), Collectors: J.M. Manuel, A.I.G. Pag-Ong.

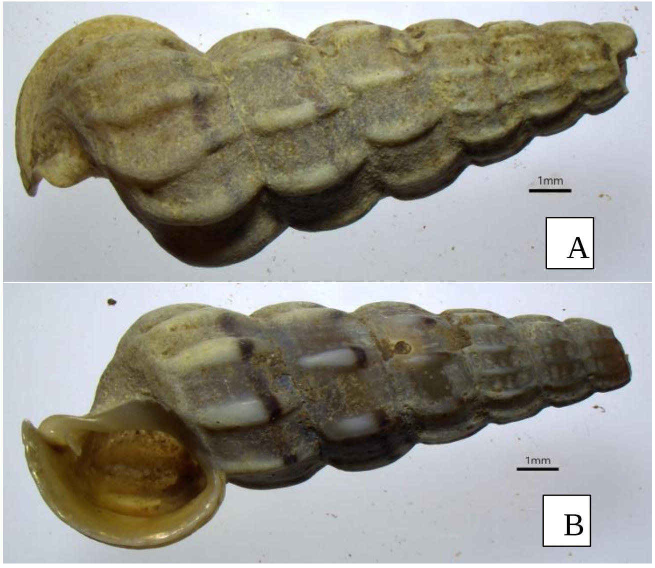
Diagnosis

The shell of *C. quoyii* (up to 45 mm), brownish green, conical, was described as broad, having a convexed spire, whorls appear flattened with their periphery to be angled. The aperture is flared, having a developed anterior canal and apertural projection. It has axial ribs on the penultimate whorl, having 6-9 whorls in total. The ventrolateral varix is enlarged and is considered dextral (Reid, 2014)

Distribution. Reid (2014) mentioned that *C. quoyii* is found within Southeast Asia, specifically on Borneo, Java, and even Philippines, with its locality in the Philippines to be seen across any littoral zone.

Remarks. Shell morphology aligns with the diagnosis of Reid (2014), with collected specimens exhibiting a conical shell with a mean length of 21 mm, the largest measuring 23 mm. The spire bears 14-32 prominent axial ribs, with a narrow to absent umbilicus and eight distinct whorls. The spire whorls appear flattened and slightly convex. The periphery is angled, with its adult lips to be flared and thickened. Aperture has a notch indicating it is not entire. The shell is dextral and colored brownish green. The dark brown coloration and robust shell structure are characteristic of species inhabiting muddy mangrove substrates, where burrowing behavior and resistance to desiccation are ecologically advantageous.

Figure 7. *Cerithidea balteata* (A) Abapertural view; (B) Apertural view. Scale bar is 1 mm.



Material Examined. PHILIPPINES, LUZON, PROVINCE OF SORSOGON, Municipality of Donsol, Ogod River, (12°53′52″ N, 123°37′52″ E), Collectors: J.M. Manuel, A.I.G. Pag-Ong.

Diagnosis

According to Reid (2014) *C. balteata* characteristics encompass a shell morphology with have rounded periphery, sometimes angled, its apertural structure to be thickened, axial ribs to be rounded, specifically on its penultimate whorl, its ventrolateral varix appears to be strong, the spiral pattern on its spire is absent, and is generally banded or lined. Often found within *Nypa* and *Sonneratia* mangroves.

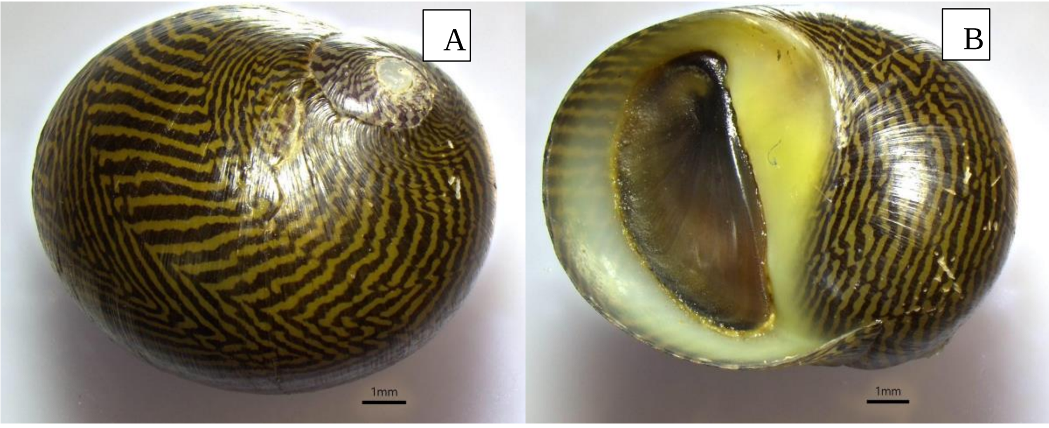
Distribution

Often found within Moluccas, New Guinea, Solomon Islands, and even the Philippines (recorded in Samar Island, Bohol, Ticao, Marinduque, Mindoro), but known to be an intertidal snail, thus appearing in almost all intertidal areas (Reid, 2014)

Remarks

The morphology of *C. balteata* appears consistent with the diagnosis of Reid (2014). The specimens present medium-sized shells (mean length 16.7 mm) with five to eight whorls. The shell is elongated and conical with strong axial ribbing, with 8-31 prominent ribs and an absent umbilicus. However, we must take note that the aperture is not complete and therefore not entire. It was also recorded to be above 1.5 from the ground, often attached to *Nypa* or *Sonneratia.*

Figure 8. *Vittina coromandeliana* (A) Abapertural view; (B) Apertural view. Scale bar is 1 mm.



Material Examined. PHILIPPINES, LUZON, PROVINCE OF SORSOGON, Municipality of Donsol, Ogod River, (12°53′52″ N, 123°37′52″ E), Collectors: J.M. Manuel, A.I.G. Pag-Ong.

Diagnosis

Shell morphology of *V. coromandeliana* include sizes up to 14 mm. Appear to be heavily globose (usually smooth, with zebralike patterns), with a dextral orientation. Columella forms plate-like structure extending across its aperture (outlined with fine serrate denticles. The operculum appears thick and has pegs, often moon shaped (able to seal apertural structure) (Velasco et al., 2018).

Distribution

V. coromandeliana are located within Indo-Pacific regions, specifically within Thailand, Japan, Indonesia, and the Philippines. Localities in the Philippines include Bohol, Cebu, and even parts of Leyte (Velasco et al., 2018).

Remarks

The specimens displayed a distinct semi-globose shell form with a mean length of 7.75 mm and two to three indistinct whorls. The shell aperture is entire and the coiling dextral, with no visible umbilicus. Its black to brown coloration, partnered with light zigzag bands, imparts a visually striking pattern typical of *Vittina* species. The shell structure of the specimen is identical to the diagnosis by Velasco et al. (2018). However, we must take note that the umbilicus is absent (not mentioned in the diagnosis) and may have different coloration/pattern (Gefaell et al., 2022).

Diversity Indices

Tables 5 and 6 show the H-index for both zones. Based on the calculated H' index, Zone 1 has a 0.3832 index value while Zone 2 has a higher index value of 1,1707. As an analysis on species richness, Zone 2 has a higher species count, with five out of six species identified collected from sampling points across Zone 2, providing a higher index value. The H' values are affected specifically in Zone 1 as the majority of the sampling points were tagged as zero collected species due to collection limitations (no soil area, and the case of high tide). When discussing the D index, it examines the likelihood of two individuals from different habitats being distinct species by chance (Warwick et al., 2008). A higher value of

Simpson's Index indicates a greater diversity within the community, suggesting a more balanced distribution of species. Conversely, a lower value indicates lower diversity and may suggest dominance by a few species. Like the H index, the D index also indicates a higher value for Zone 2, with an index value of 0.6818 compared to Zone 1, with an index value of 0.29 (presented in Tables 7 and 8). The lower index value indicates the dominance of some species. The dominance of a *C. balteata* in Zone 1 affected the index value. Similar to the H' values, the D index is affected due to sampling limitations. For the C index, value comparison for both sites accounted for 0.5, indicating moderate similarity between the two zones. The results are based on the analysis that only 2 species are present in both zones when compared to the 3 species in Zone 1 and 5 species in Zone 2.

Table 5. Shannon-Wiener Index (H') of Zone 1

Species Name	Zone 1								
	SP1	SP2	SP3	SP9	SP10	TOTAL	P	lnP	PlnP
Littoraria intermedia	0	0	0	0	0	0	0	0	0
Littoraria pallescens	0	0	0	0	0	0	0	0	0
Littoraria lutea	0	3	0	0	0	3	0.12	-2.120	-0.254
Cerithidea quoyii	0	0	0	0	0	0	0	0	0
Cerithidea balteata	0	0	21	0	0	21	0.84	0	0
Vittina coromandeliana	0	1	0	0	0	1	0.04	-3.219	-0.129
					Total	25	1	-5.339	-0.383
								H' =	**0.3832**

Table 6. Shannon-Wiener Index (H') of Zone 2

Species Name	Zone 2								
	SP4	SP5	SP6	SP7	SP8	TOTAL	P	lnP	PlnP
Littoraria intermedia	1	4	0	1	0	6	0.11	-2.251	-0.237
Littoraria pallescens	0	4	2	3	8	17	0.30	-1.210	-0.361
Littoraria lutea	6	22	2	0	0	30	0.53	-0.642	-0.338
Cerithidea quoyii	0	0	2	0	0	2	0.04	-3.350	-0.118
Cerithidea balteata	0	0	0	0	0	0	0.000	0	0
Vittina coromandeliana	0	0	1	0	1	2	0.04	-3.350	-0.118

	Total	57	1	-10.803	-1.171
				H' =	**1.1707**

Table 7. Calculated Simpson's Index of Diversity (D) of Zone 1

Species Name	**Zone 1**							
	SP 1	**SP 2**	**SP 3**	**SP 9**	**SP10**	**TOTAL (n)**	**n-1**	**n(n-1)**
Littoraria intermedia	0	0	0	0	0	0	-1	0
Littoraria pallescens	0	0	0	0	0	0	-1	0
Littoraria lutea	0	3	0	0	0	3	2	6
Cerithidea quoyii	0	0	0	0	0	0	-1	0
Cerithidea balteata	0	0	21	0	0	21	20	420
Vittina coromandeliana	0	1	0	0	0	1	0	0
					Total (N)	**25**		**426**

Table 8. Calculated Simpson's Index of Diversity (D) of Zone 2

Species Name	**Zone 1**							
	SP 4	**SP 5**	**SP 6**	**SP 7**	**SP8**	**TOTAL (n)**	**n-1**	**n(n-1)**
Littoraria intermedia	1	4	0	1	0	6	5	30
Littoraria pallescens	0	4	2	3	8	17	16	272
Littoraria lutea	6	22	2	0	0	30	29	870
Cerithidea quoyii	0	0	2	0	0	2	1	2
Cerithidea balteata	0	0	0	0	0	0	-1	0
Vittina coromandeliana	0	0	1	0	1	2	1	2
					Total (N)	**57**		**1176**

Zone 1

D Index of Diversity = 1-∑n (n-1)/N(N-1)

∑n (n-1) = 426

N(N-1) = 25(25-1) = 25 x 24 = 600

D = 1-∑n (n-1)/N(N-1)

D = 1 - (426/600)

D = 1 – 0.71

D = 0.29

Zone 2

D Index of Diversity = 1-∑n (n-1)/N(N-1)

∑n (n-1) = 1176

N(N-1) = 57(57-1) = 56 x 55 = 3080

D = 1-∑n (n-1)/N(N-1)

D = 1 - (1176/3080)

D = 1 – 0.3818

D = 0.6818

Sorensen Similarity Index (C)

C = 2S/(A+B)
C = 2(2) / (3+5)
C = 4/8
C = 0.5

Discussion

The *Littoraria* is the most abundant genus from the collection, with three species present out of the six total collected species. This has been expected since *Littoraria* spp. are recognized as the mangrove periwinkle (WoRMS Editorial Board. (2023). This aligned with the results and is consistent with the findings of Baderan et al. (2019), highlighting the abundance of *Littoraria* in aquatic environments featuring mangrove species along the coastal regions of Indonesia. This also aligns with the role of *Littoraria* spp. present within multiple leaf litters along mangroves, typically acting as decomposers for nutrient cycling (Graca, 2001). Meanwhile, *Cerithidea* was also abundant from the collected specimens, accounting to two species present out of the six total collected species. Although Farahisah et al (2023) indicated no correlation between mangrove abundance and *Cerithidea* spp. abundance, they still mentioned that it is important to take note that aside from its suitable environment in terms of climactic factors, the high amount of leaf litter produced by mangrove gives food for gastropods for nutrient cycling purposes and thus might be a potential reason for the abundance of the gastropod within mangrove regions.

As depicted in Table 2, the sizes of the gastropods exhibit a small range, spanning from 6 mm to 30 mm, and those exceeding 50 mm are notably absent during the specified period. This absence may be attributed to the potential predation of gastropods by firefly species. Larger-sized gastropods tend to release significant amounts of slime-like substance called mucin, which firefly larvae track, facilitating the easy tracing of their locations (Sato, 2019). Furthermore, it is commonly believed that gastropods thrive better in environments with higher moisture content. Consequently, one might anticipate a higher abundance of gastropods in the borderline water regions along the river stretch (McKillup & McKillup, 2000). However, the collected gastropods are primarily situated within the leaf and stem of mangroves (based on observation), aligning with the potential predation by fireflies, given that these insects typically lay their eggs in damp soil, tree roots, and water (Lloyd, 2006).

Additionally, some species of gastropods, like Nerite gastropods (Family Neritidae) are typically classified as arboreal, dwelling in trees. While some gastropods belonging to the Family Littorinidae are also arboreal, the majority are recognized as intertidal dwellers or semi-terrestrial gastropods (McKillup & McKillup, 2000). In accordance with Sato's (2019) investigation, experimental procedures have indicated a preference among firefly larvae for arboreal to semi-arboreal gastropods as a food source compared to terrestrial ones. This preference potentially explains the higher abundance of *Littoraria* species, which are terrestrial or soil-dwelling, in comparison to Nerites.

In *L. pallescens*, there has been variability among shell morphology, specifically on its polymorphism in terms of color. This difference has been attributed to shell strength. According to Cook & Kenyon (1993), the darkly pigmented shells (cream and brown) tend to have a stronger structure and are thicker and heavier compared to the light-colored shells (yellow and red). A report by Mantiri et al. (2023) also showed the same result when assessing the four shades of the gastropod shell. However, it is to be noted of the location of the gastropod in relation to the mangrove tree part. Results still from Mantiri et al. indicated the abundance of yellow and brown colored shells within leaf parts compared to red and cream, which are low in the leaf parts. Surprisingly, no yellow- red- and cream-colored shells are seen within the branch and root parts of the tree. This data aligned with the collections of this study, wherein yellow and red colored shells were collected within leaf parts while the dark colored (brown) are gathered mostly in the roots.

Like fireflies, gastropods demonstrate a higher abundance in mangroves characterized by an elevated Diameter at Breast Height (DBH), as observed by Pogado & De Chavez (2022). There seems to be a positive correlation between higher tree density and increased gastropod abundance (Lestariningsih et al., 2020). This concurs with the selected sampling points, where SP5 and SP3 feature *Sonneratia* sp. and *Avicennia* sp., both exhibiting relatively high DBH (Loría-Naranjo et al., 2015), along with enhanced tree density (Lestariningsih et al., 2020). Notably, the sampling points where *L. lutea*. and *C. balteata* were collected, coincide with SP3 and SP5.

When comparing the Diversity indices for both zones, both H' and D have big differences, with H" index values of 0.3832 and 1.1707 for Zones 1 and 2, and D index values of 0.29 and 0.6818, respectively. The big difference can be attributed to the collection limitations and the zonation protocol. Rahmawati et al. (2021) mentioned that higher diversity is seen in places where there is high richness and evenness. Moreover, she added that environmental factors and even the presence of competition and predators can be a cause of differences in diversity. Zone 1 is tagged as SPs away from anthropogenic activities (not anthropogenic). It was classified as a anthropogenic zone due to the minimal presence of human settlements and the absence of man-made structures. The area is predominantly covered with mangrove vegetation, creating a relatively undisturbed natural habitat. Personal observations (visual) recorded a higher abundance of fireflies within the SPs in Zone 1. This pattern suggests that the zone's condition supports favorable ecological conditions for fireflies. However, the same area exhibited a lower relative abundance and diversity of gastropods, as reflected in the diversity indices. This could imply the predatory behavior and event of firefly larvae and other fauna that may contribute to reduced gastropod number in the area (Ramdwar et al., 2023).

In contrast, Zone 2 was tagged as an anthropogenic zone due to its proximity to the Putiao-Pilar Road Bridge and the main ecotourism site or office. The presence of residential structures and man-made fishponds surrounding the river in Zone 1 indicates significant human influence. This zone exhibited higher gastropod diversity and abundance but lower firefly activity, likely due to light pollution and habitat disturbance. The increased gastropod populations may also be attributed to elevated nutrient levels in the water and soil resulting from anthropogenic inputs, which enhance food availability for these organisms (Wattanachaiyingcharoen et al., 2016).

Conclusion

Undoubtedly, the Ogod River in Donsol, Sorsogon, harbors a diverse array of gastropod species. Among them, *Littoraria lutea (R. A. Philippi, 1847)* stands out with the highest frequency, totaling 34 specimens, followed by *Cerithidea balteata* A.Adams, 1855 with 21 specimens. Additional species, including *Littoraria intermedia* (R.A. Philippi, 1846), *Littoraria pallescens* (R. A. Philippi, 1846), and *Cerithidea quoyii* (Hombron & Jacquinot, 1848), and *Vittina coromandeliana* (G.B.Sowerby I, 1836) were also identified. However, it is crucial to acknowledge the limitations of this paper, which solely focuses on a preliminary identification of gastropods as potential prey for firefly larvae. Therefore, a recommended course of action involves conducting a continuous survey of gastropods to achieve a more comprehensive understanding of the gastropod community within the Ogod River in Donsol, Sorsogon. Moreover, there are no existing reports on the visual observation of firefly larvae consuming gastropods in the mentioned area, making it a noteworthy field for future studies. In this regard, exploring concepts such as molecular protocols to determine the potential ingestion of gastropod species by fireflies is also advised. The Philippines, particularly in Donsol, Sorsogon experience climatic conditions like tropical monsoon climate characterized by high humidity, heavy rainfall, and distinct dry and wet seasons which can influence the distribution and abundance of gastropods and fireflies affecting ecological dynamics within Ogod River. Lastly, water quality parameters prescribed by DENR such as physical factors (temperature, color, total suspended solids (TSS)), chemical factors (pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and other organic and inorganic substances), and microbiological factors (coliform, fungal spores, etc.) may also have fluctuations. Thus, assessing these factors can be considered to achieve a more comprehensive and holistic analysis.

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AI Declaration

This paper was completed with assistance from Artificial Intelligence (AI Tools). ChatGPT was used to summarize the main points of the references for easier understanding. Grammarly was employed for grammar and style checking. Google Scholar and other databases were used to locate relevant peer-reviewed literature. All outputs from these used AI tools were critically reviewed and assessed by the author to ensure accuracy and integrity.

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